(51) **International Patent Classification:**
H04N 13/00 (2006.01)   G02F 1/1335 (2006.01)

(21) **International Application Number:**
PCT/NZ2005/000253

(22) **International Filing Date:**
30 September 2005 (30.09.2005)

(25) **Filing Language:** English

(26) **Publication Language:** English

(30) **Priority Data:**
535732   1 October 2004 (01.10.2004)   NZ

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(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),

(54) **Title:** IMPROVED STEREOSCOPIC DISPLAY
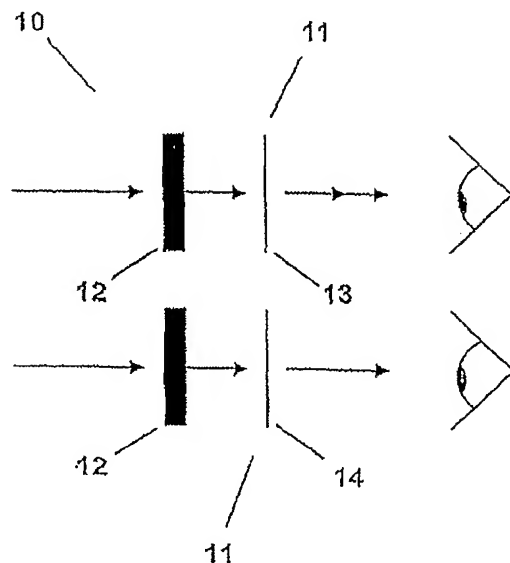
(57) **Abstract:** The present invention relates to a stereoscopic display adapted to present a stereoscopic image composed of a plurality of pixels. This display includes a light intensity encoder adapted to emit light from a plurality of pixels with an assigned light intensity for each pixel, and a light polarisation encoder adapted to receive light emitted from the light intensity encoder and to emit this light within an assigned polarisation state for each pixel. The display provided is adapted to emit light polarised with a non-spatial polarisation. The present invention also encompasses a stereoscopic image decoder which includes two polarisation filters with each filter to be positioned between a stereoscopic display and an eye of an observer.

WO 2006/038819 A1

European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

—   *with international search report*

—   *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

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IMPROVED STEREOSCOPIC DISPLAY

TECHNICAL FIELD

This invention relates to improvements in or relating to stereoscopic displays and methods of manufacturing said displays. In particular the present invention may be adapted to provide a stereoscopic display which allows an observer to view an

5   image with stereoscopic qualities where the image viewed is consistent irrespective of the viewing angle or viewing orientation of the observer.

BACKGROUND ART

In numerous and varied applications it would be of advantage to have some form of stereoscopic display system. These types of displays may present an image to

10   an observer with three-dimensional qualities or spatial depth cues. This additional depth or stereoscopic information can be useful in many different fields ranging from entertainment through to controlling remotely operated vehicles, robotic systems, or remote sensing devices for example.

A standard technique employed in existing stereoscopic display systems is to

15   present a spatially displaced image to either eye of an observer. Two separate, slightly displaced images may be presented to the eyes of an observer to provide the observer with a depth cue and hence the perception of a three-dimensional image on the display.

These two spatially displaced images can be encoded for the alternate eyes of an

20   observer using light polarisation systems. One image may be composed from a specific state of linear polarisation of light which can be blocked by a polarising filter over the alternate eye of the observer which is not to view the image. This approach can be made with the second image using a second state of linearly polarised light to ensure that each eye of the observer only observes one of the

two images presented.

An example of an implementation of this type of technology is disclosed in US patent number US 6181303.

This patent discloses the implementation of a stereoscopic display system which employs liquid crystal display technology. The observer of the display wears a set of glasses with appropriate polarisation filters to obtain views of two slightly displaced images of the scene for a stereoscopic effect.

The system disclosed in this patent employs an initial rear liquid crystal display to present a single output image with a specific light intensity per pixel of the image. A second front liquid crystal display is then used to apply a variable spatial polarisation to the output of the rear LCD. This system in effect encodes two pixels with intensities I_1, I_2 into a single pixel, with an intensity I_3 and a polarisation rotation state. Polarisation filters worn over the eyes of the wearer then decompose the single intensity value of I_3 combined with the polarisation rotation state into a single image intensity I_1 for one eye and the second image of intensity I_2 for the second eye of the observer.

However, there are some limitations present in this particular LCD implementation of a stereoscopic display system.

A spatial based polarisation is applied and present in the output of the display which is subsequently decoded by the lenses or filters worn over the eyes of an observer. However, due to the spatial nature of the polarisation applied, variations in the viewing position or viewing orientation of an observer's eyes will result in variations in the final image observed.

For example, if an observer were to tilt their head, the linear or spatial polarisation used in the output of the display could potentially swap the images presented to

each eye of the observer. This effect can be a significant disadvantage in environments where the observer is frequently moving or angling their head such as in instances where vehicles or robotic systems are to be controlled mainly using the images observed.

5   An improved stereoscopic display that would address the above issues would be of advantage. In particular a stereoscopic display which could be implemented using existing liquid crystal display technology and which also presented a consistent stereoscopic image to an observer, irrespective of the observer's point of view or orientation of view would be of advantage.

10   All references, including any patents or patent applications cited in this specification are hereby incorporated by reference. No admission is made that any reference constitutes prior art. The discussion of the references states what their authors assert, and the applicants reserve the right to challenge the accuracy and pertinency of the cited documents. It will be clearly understood that, although a

15   number of prior art publications are referred to herein, this reference does not constitute an admission that any of these documents form part of the common general knowledge in the art, in New Zealand or in any other country.

It is acknowledged that the term 'comprise' may, under varying jurisdictions, be attributed with either an exclusive or an inclusive meaning. For the purpose of this

20   specification, and unless otherwise noted, the term 'comprise' shall have an inclusive meaning - i.e. that it will be taken to mean an inclusion of not only the listed components it directly references, but also other non-specified components or elements. This rationale will also be used when the term 'comprised' or 'comprising' is used in relation to one or more steps in a method or process.

25   It is an object of the present invention to address the foregoing problems or at least to provide the public with a useful choice.

Further aspects and advantages of the present invention will become apparent from the ensuing description which is given by way of example only.

DISCLOSURE OF INVENTION

According to one aspect of the present invention there is provided a stereoscopic
5   display adapted to present a stereoscopic image composed of a plurality of pixels, the display including,

a light intensity encoder adapted to emit light from a plurality of pixels with an assigned light intensity for each pixel, and

a light polarisation encoder adapted to receive light emitted from the light intensity
10   encoder and to emit said light with an assigned polarisation state for each pixel,

wherein the light polarisation encoder is adapted to emit light polarised with a non-spatial polarisation.

According to a further aspect of the present invention there is provided a stereoscopic display substantially as described above which includes an intensity
15   assignment processor adapted to determine the light intensity to be assigned to each pixel of the image to be displayed.

According to another aspect of the present invention there is provided a stereoscopic display substantially as described above which also includes a polarisation assignment processor adapted to determine the polarisation state to
20   be assigned to each pixel of the image to be displayed.

According to yet another aspect of the present invention there is provided a stereoscopic image decoder which includes two polarisation filters with each filter to be positioned between a stereoscopic display and an eye of an observer of said stereoscopic display,

wherein the first polarisation filter is adapted to block non-spatially polarised light in a first polarisation state, where said non-spatially polarised light in a first polarisation state is emitted by the second polarisation filter, and

the second polarisation filter is adapted to block non-spatially polarised light in a second polarisation state, wherein said non-spatially polarised light in a second polarisation state is emitted by the first polarisation filter.

According to yet another aspect of the present invention there is provided a stereoscopic display system which includes a stereoscopic display and at least one stereoscopic image decoder substantially as described above.

According to a further aspect of the present invention there is provided computer readable instructions which when run are adapted to provide an intensity assignment processor of a stereoscopic display substantially as described above.

According to yet another aspect of the present invention there is provided computer readable instructions which when run are adapted to provide a polarisation assignment processor of a stereoscopic display substantially as described above.

The present invention is adapted to provide preferably both a stereoscopic display and also a stereoscopic image decoder to be employed by an observer of such a display.

Reference throughout this specification will also be made to the stereoscopic display provided being used to present a stereoscopic image. Such an image may be in effect composed of two separate slightly spatially displaced images of essentially the same scene where each of these two displaced images are to be presented to either eye of an observer, or in other instances to two or more observers. Preferably the image presented in the output of the display may be

composed of or formed from a plurality of pixels, being individual picture elements which when viewed together form the stereoscopic image required. Those skilled in the art should appreciate that stereoscopic images in general which employ the presentation of two slightly spatially displaced images are well known in the art.

5   Reference throughout this specification will also be made to the present invention applying a specific light intensity and polarisation encoding to individual pixels of a display. However those skilled in the art should appreciate that such treatment, may be applied to both single pixels or groups of related or adjacent pixels if required. The batch or group processing of pixels as opposed to single pixels may

10   in some instances allow lower cost componentry to be used in conjunction with the present invention or allow for the faster operation of processing systems employed in relation to same. Reference throughout this specification to the present invention acting on single pixels only should no way be seen as limited.

In a preferred embodiment the stereoscopic display provided may include a light

15   intensity encoder. Such a light intensity encoder can be adapted to emit light from a plurality of pixels where each pixel has an assigned light intensity value or intensity. Preferably the light the intensity encoder may be adapted to control the luminous light intensity of a plurality of pixels adapted to form a stereoscopic image.

20   Preferably a light intensity encoder may be provided by a device that can emit light over a given range of intensities. In a further preferred embodiment, such a device may incorporate many small pixels that can be individually controlled and arranged into a pattern (such as for example, LCD, LED, SED technology).

In a further preferred embodiment the light intensity emitted for a pixel maybe

25   determined at least in part by the light intensities of pixels making up the two spatially displaced images of the scene which the display is to present.

In a preferred embodiment the stereoscopic display provided may include a polarisation encoder which is adapted to receive light emitted from the light intensity encoder. Light emitted from the light intensity encoder will be composed of a plurality of pixels with individually assigned light intensity values which are

5   received as an input by the light polarisation encoder.

Reference throughout this specification will also be made to the polarisation encoder receiving light transmitted or emitted from the light intensity encoder. However those skilled in the art should appreciate that in an alternative embodiment potentially the order of these two components may be reversed. In

10 such instances the light intensity encoder may be adapted to receive light emitted or transmitted from the polarisation encoder.

Reference is also being made throughout this specification to the present invention emitting light from either or both the intensity and polarisation encoders. Those skilled in the art should appreciate that the use of the term "emit" should

15 encompass both the generation of light by a particular component in addition to a component allowing light from an alternate source to pass through or be transmitted through itself. Those skilled in the art should appreciate that either approach may readily be used in conjunction with the present invention and reference to the term "emit" or "emission" should in no way be seen as limiting.

20 Those skilled in the art should appreciate that reference to the intensity encoder providing light as an input to the polarisation encoder should in no way be seen as limiting.

Preferably the light polarisation encoder may be adapted to re-emit light received from the light intensity encoder where the polarisation's state of light from each

25 pixel is controlled, modified or assigned by the light polarisation encoder. The light intensities of the pixels making up the pair spatially displaced images of the

required stereoscopic image may be used to determine the polarisation state assigned by the light polarisation encoder.

Preferably the intensity encoder and light polarisation encoder may be used to encode the light intensities of two corresponding pixels into a single pixel's output light intensity and polarisation state value. Preferably a stereoscopic image decoder may then be employed by an observer of the display to subsequently decompose the polarisation state and intensity value assigned to each pixel displayed into the original pair of spatially displaced light intensities encoded by the stereoscopic display.

In a preferred embodiment the stereoscopic display may also include an intensity assignment processor adapted to calculate or assign a specific light intensity to each pixel making up the stereoscopic image to be presented. Furthermore, a display provided in accordance with the present invention may also include a polarisation assignment processor adapted to calculate or assign a polarisation state to each pixel of the stereoscopic image to be presented. Such processors may be implemented through software or computer readable instructions loaded into a microprocessor or other similar type of programmable logic device. Alternatively, analogue electronics may be employed to implement such processors if required. Furthermore, in some instances a single microprocessor may be programmed to implement both the intensity assignment and polarisation assignment processes if required.

In a further preferred embodiment the light intensity and polarisation state assigned to each pixel displayed may be dictated directly by a function of both the light intensities of the corresponding pixels of a pair of spatially displaced images used to create the stereoscopic image.

In the preferred embodiment a light intensity encoder may be implemented through

the use of a liquid crystal display (LCD).   LCDs are well known in the art and employ a backlight which feeds white light into a linear polariser, liquid crystal matrix and then subsequently through a further linear polariser in the transmission path of the liquid crystal matrix. The orientation of the liquid crystals in the matrix is

5   adjusted by an electric field to in turn adjust the intensity of light emitted from the matrix through the last linear polarisation filter. Liquid crystal displays can be readily implemented using existing technology and can be easily employed and driven to present a pixel based image with an assigned light intensity value associated with each pixel.

10   Reference throughout this specification will also be made to a light intensity encoder being implemented through the provision of a liquid crystal display system. However, those skilled in the art should appreciate that other types of pixel based light intensity controlling display systems may also be employed in conjunction with the present invention, and reference to the above only through out this

15   specification should in no way be seen as limiting.   For example in other embodiment projector based systems, or alternatively exiting cathode ray tube to technology may also be employed to provide a light intensity encoder in alternative embodiments.

Reference through out this specification will also be made to the LCD used as an

20   intensity encoder also including a further linear polariser in the front of or in the transmission path of the liquid crystal matrix which filters light emitted or transmitted by this matrix. However those skilled in the art should appreciate that in alternative embodiments this additional linear polariser may be dispensed with if required, depending on the specific components employed to provide the present

25   invention.

Preferably the polarisation encoder provided may control the polarisation state of light emitted from the stereoscopic display.

Preferably the polarisation state assigned for a pixel of the display may be determined at least in part by the intensities of pixels making up two spatially displaced images of the scene which the stereoscopic display is to present.

Preferably the light polarisation encoder is adapted to emit or re-emit light from
5   each pixel with a non-spatial polarisation. Non-spatial polarisation states may be applied to the light from each pixel to eliminate variations observed in the stereoscopic image presented to an observer depending on the observers view point or view orientation.

The polarisation state assigned to each pixel of the stereoscopic image is
10   preferably non-spatially polarised. Spatially polarised light observed through a linear polarisation filter is perceived variably depending on an observer's or sensor's spatial orientation and position. For example, linearly polarised light is spatially polarised as it travels in a plain wave through space. If an observer were to wear a linear polarisation filter over each of their eyes a linearly polarised light
15   wave would only be observer clearly from one specific view orientation or position. Conversely, with non-spatially polarised light the view orientation or angle of an observer will not modify the observers perception of the light emitted. A non-spatial polarisation applied to light may include the provision or presence of right or left hand circularly polarised light.

20   In a preferred embodiment, a polarisation encoder may include a twisted nematic liquid crystal matrix adapted to receive a light from the light intensity encoder.

In a further embodiment of the present invention the polarisation encoder may include a quarter wave retarder component.

In a further preferred embodiment a light polarisation encoder may be implemented
25   through the combination of a twisted nematic liquid crystal matrix configured to emit light received from light intensity decoder through to a quarter wave retarder

component.

The twisted nematic LCD technology provided may be used to control angular rotation in the linearly polarised light provided by the light intensity encoder, and therefore rotate the polarisation state of this light per pixel.

5   The quarter wave retarder component may then receive the rotated linearly polarised light from each pixel and subsequently convert the linearly polarised light to ecliptically polarised light having a non-spatial polarisation state.

Elliptically polarised light has a phase differential present at the electro-magnetic waves composing the light involved, as opposed to a spatial differential present

10   with a spatially polarised light wave.   This phase differential in the elliptically polarised light then caries the assigned polarisation state information required to allow the image observed from the display to be decomposed back into the two original source images.

Reference throughout the specification will also be made to the light polarisation

15   encoder being implemented through the combination of a twisted nematic liquid crystal display and a quarter wave retarder system. However, those skilled in the art should appreciate that other forms of light polarisation encoders which can emit non-spatially polarised light with an assigned polarisation state per pixel may also be employed in conjunction with the present invention. However, reference to the

20   above only throughout this specification should in no way be seen as limiting.

In some embodiments additional components or elements may also be located between the light intensity encoder and polarisation encoder. For example, in some instances diffusing elements used to scatter light can be employed to break up moiré interference patterns. Alternatively refractor components may be

25   employed to align or control the transmission pathways of light through the display provided. Those skilled in the art should appreciate that additional filter elements

or components may also be employed between the encoders of the present invention if required.

Preferably the stereoscopic display provided may also be used to display colour images. Those skilled in the art should appreciate that many image colouring technologies may be employed to achieve this aim of the present invention. For example, standard LCD colour filters can be employed with both or either of the intensity and polarisation encoders or alternatively field sequential lighting techniques may alternatively be employed. The present invention may be configured as either a colour display or alternatively black and white/grey scale display if required.

According to a further aspect of the present invention there is provided a method of providing an intensity assignment processor through computer readable instructions, said instructions being adapted to execute of the steps of;

i)   determining an intensity value for at least one pixel of a left input image, defined as I_l for each pixel investigated, and

ii)   determining an intensity value for at least one pixel of a right input image, defined as I_r for each pixel investigated, and

iii)   calculating the intensity to be assigned by the intensity assignment processor provided, said assigned intensity defined as I_a, being proportional to

$$I_a \, \alpha \, \sqrt{(I_l)^2 + (I_r)^2}$$

According to a further aspect of the present invention there is provided a method of providing a polarisation assignment processor through computer readable instructions, said instructions being adapted to execute of the steps of;

i)   determining an intensity value for at least one pixel of a left input image, defined as I_l for each pixel investigated, and

ii)   determining an intensity value for at least one pixel of a right input image, defined as I_r for each pixel investigated, and

5   iii)   calculating the polarisation to be assigned by the intensity assignment processor provided, said assigned polarisation defined as P_a being proportional to

$$P_a \; \alpha \; \arctan \left(I_r / I_l \right)$$

Those skilled in the art should also appreciate that a set of computer executable

10 instructions stored on a computer readable medium are within the scope of the present invention, where these instructions are adapted to provide the polarisation assignment and/or intensity assignment processors discussed above.

In some embodiments an intensity assignment processor may receive left and right intensity information from pairs of stereoscopic images and return a signal to

15 control the operation of the light intensity encoder. Such a processor may incorporate electronics which receive an input signal from a stereoscopic media generator where the stereoscopic media involved consists of left and right image pairs.

In some embodiments a polarisation assignment processor as discussed above

20 may receive left and right hand intensity information and return a signal to control the operation of the light polarisation encoder. Such a processor may incorporate electronics that receive a signal again from a stereoscopic media generator which again works with stereoscopic media composed of left and right image pairs.

In a further preferred embodiment the intensity and/or polarisation assignment

25 processor discussed above may be adapted to deal with colour or RGB based

images. In the example discussed below a light intensity encoder may effectively present a rear set of pixels whereas a light polarisation encoder may present a forward set of pixels.

Now considering two RGB images, being a left/right pair to calculate the front/back pair where we treat each pixel separately. Using the same spatial pixel from each left/right image we calculate the front/back pixels according to the equations set out below, where a single left pixel is represented by a red, green and blue component (R, G, B)

$$(R_b, G_b, B_b) = (\sqrt{(R_l^2 + R_r^2)}, \sqrt{(G_l^2 + G_r^2)}, \sqrt{(B_l^2 + B_r^2)}) / \sqrt{2}$$

$$(R_f, G_f, B_f) = (510 * (\arctan(R_r / R_l), \arctan(G_r / G_l), \arctan(B_r / B_l)) / \Pi$$

If the left pixel was (R, G, B) = (255, 150, 10) and the right pixel was (R,G,B) = (255, 100, 0). The following describes how to calculate the front and back pixel.

To calculate a rear pixel we have

$$RGB = (\sqrt{(255^2 + 255^2)}, \sqrt{(150^2 + 100^2)}, \sqrt{(10^2 + 0^2)})$$

$$= (360.6, 180.3, 0) \ (1dp)$$

Obviously now the values are no longer integer and in the range (0, 255) so we divide by $\sqrt{2}$ and round appropriately.

$$= (\sqrt{2} / (360.6, 180.3, 10))$$

$$= (255, 127, 7)$$

So the rear pixel is RGB (255, 127, 0)

Now to calculate the front pixel we have

$$RGB = (\arctan(255 / 255), \arctan(100 / 150), \arctan(10 / 0))$$

$$= (0.7854, 0.5880, 1.5708)$$

Here we have a similar problem. The inverse tan gives a value in the range from (0, Π / 2) so to rescale to (0, 255) we multiply by 255 * 2 / Π

$$= (255 * 2 / Π * (0.7854, 0.5880, 1.5708))$$

5                              $$= (128, 95, 255)$$

In a preferred embodiment the present invention may also be used to provide a stereoscopic image decoder. Such a decoder may include a pair of polarisation filters to be positioned between a stereoscopic display and at least one eye of an

10   observer of such a display. The polarisation filters employed may be used to translate the light intensity and polarisation state information present in each pixels light into an intensity value for two independent pixels of two spatially displaced images.

Preferably these pair of polarisation filters may be matched or complimentary in

15   nature so that one filter will block non-spatially polarised light with a first polarisation state where this light is subsequently passed or emitted by the second polarisation filter. Conversely second polarisation filter may pass or emit light with a second polarisation state which is in turn blocked by the first polarisation filter.

Those skilled in the art should appreciate that reference to blocking of light in

20   conjunction with the present invention may encompass absorption, reflection, scattering, diffusion or otherwise any other method of preventing light from being observed by or being incident with the eyes of an observer.

This configuration of the image decoders polarisation filters allows each eye of an observer or independent observers to resolve an independent or separate image.

Each independent image presented may be slightly spatially displaced to in turn give observers image depth cues. Those skilled in the art should appreciate that the pair of polarisation filters provided may be worn over either eye of a single observer or may be worn over the eyes of different observers located at different perspectives if required. The general discussion throughout this specification of a single observer only being involved should in no way be seen as limiting.

In a further preferred embodiment a polarisation filter of a stereoscopic image decoder may consist of or incorporate a quarter wave retarder combined with a linear polarisation filter. A quarter wave retarder may be used to remove the elliptical polarisation applied to light received from a display while a linear polarisation filter can be used to block or emit lights with specific spatial polarisation characteristics or states.

Reference throughout this specification will also be made to the polarisation filters of a stereoscopic image decoder including the quarter wave retarder and linear polarisation filters discussed above. However, those skilled in the art should also appreciate that the specific components employed in the construction of the stereoscopic display involved will to some extent dictate the constructional or form of the polarisation filters involved. For example, in an alternative embodiment a single combined filter may be employed to decode or decompose the light emitted by the display without necessarily needing to rely on a separate linear polarisation filter or filters as discussed above.

The present invention may provide many potential advantages over the prior art.

A stereoscopic display system including a display and at least one image decoder can be used to present stereoscopic images which cannot vary depending on the view position or view angle of an observer. The use of non-spatially polarised light transmissions and the operation of such a display can therefore be employed to

provide consistent and reprogressional views of an image with stereoscopic depth quality.

A stereoscopic display as configured in accordance with the present invention may also be configured to present basic two dimensional images without any

5   stereoscopic effect. Simply by disabling the operation of the polarisation encoder and removing the image decoder such a display may operate as a standard two dimensional liquid crystal display in some embodiments.

In addition the present invention may be used to provide a higher resolution stereoscopic display than some of forms of existing stereoscopic displays. This

10   present invention does not use alternate pixels presented to each eye, or the pixels which are multiplexed in time, thereby allowing the overall resolution of the display to be increased.

BRIEF DESCRIPTION OF DRAWINGS

Further aspects of the present invention will become apparent from the following

15   description which is given by way of example only and with reference to the accompanying drawings in which:

Figure 1   shows a top cross section schematic view of a stereoscopic display as configured in accordance with a preferred embodiment of the present invention, and

20   Figure 2   shows a top cross section schematic view of an image decoder as configured in accordance the same embodiment of the invention discussed with respect to Figure 1.

BEST MODES FOR CARRYING OUT THE INVENTION

Figure 1 shows a top cross section schematic view of a stereoscopic display as

configured in accordance with a preferred embodiment of the present invention.

The display (1) is formed from two main components, being a light intensity encoder (2) and a light polarisation encoder (3).

In the embodiment shown the light intensity encoder (2) is formed from a light source in the form of a backlight form which projects or emits non-polarised white light towards a first linear polarisation filter (5). This first linear polariser (5) then emits light with a specific spatial linear polarisation state through to the rear of a liquid crystal matrix (6). The orientation of each of the crystals arrayed within the matrix (6) is adjusted using an electric field to apply a specific light intensity value to each pixel making up or composing the matrix (6). Light subsequently emitted from the liquid crystal matrix (6) is then filtered through a further linear polarisation filter (7) and subsequently emitted from the front of the light intensity encoder assembly (2).

The light emitted from the intensity encoder is composed of a plurality of pixels with a defined or set light intensity value for each pixel. The light emitted is substantially linearly polarised and used as an input for the following polarisation encoder (3).

The electric field applied across the liquid crystal matrix (6) is employed to directly control the light intensity of each pixel used to make the display. An intensity assignment processor (not shown) is used to calculate the specific intensities to be assigned to each pixel. These intensities are based in part on the intensities of a pair of corresponding pixels making up two spatially displaced stereoscopic images of a scene to be presented by the display (1).

The polarisation encoder (3) receives at its rear the intensity coded linearly polarised light emitted from the light intensity encoder (2). This light is received by a combination of components, the first of same being a twisted nematic crystal

filter (8). The twisted nematic filter (8) is employed to apply a rotational translation to the linearly polarised light it receives. This rotational translation can be varied for each pixel of the twisted nematic crystal making up the display so that variable rotation will be applied to each pixel's light to in turn apply an assigned polarisation

5   state to this light.

Those skilled in the art should also appreciate that there may be some approximation present in the operation of the encoder due to the overlapping of light supplied from adjacent pixels of the intensity encoder.

The subsequently rotationally translated linearly polarised light is them emitted

10   through the twisted nematic filter (8) and fed through as an input through a quarter wave retarder component (9). The quarter wave retarder (9) is used to translate rotated linearly polarised light emitted from the twisted nematic filter through to elliptically polarised light. A blanket transformation is applied by the quarter wave retarder across the light of all pixels of the display, translating this initially spatially

15   polarised light through to a non-spatially polarised light to be emitted from the front of the display provided.

The operation of the twisted nematic filter (8) is driven by a polarisation assignment processor (not shown) which calculates the polarisation state to be applied to light from each pixel exiting the front of the filter (8). Such processor may calculate a

20   required polarisation state for each pixel of the display with this polarisation status being dictated by both the light intensity of the pixel and also the light intensities of pixels making up two corresponding source images to be displayed.

This configuration of both the light intensity encoder (2) and light polarisation encoder (3) allows a stereoscopic image composed of a plurality of pixels to be

25   emitted with light from each pixel having a non-spatially polarised state. This non-spatially polarisation and intensity encoded light can then be subsequently

decomposed by the stereoscopic image decoder discussed with respect Figure 2.

This type of display system may be implemented in a "sandwich" configuration, with a more compact embodiment than that shown in the schematic view of figure 1. In such instances any voids or spaces may be eliminated between the layered

5   components to provide a relatively compact display design.

Figure 2 illustrates a stereoscopic image decoder (10) formed from a pair of polarisation filters (11). Each filter (11) is in turn composed of a quarter wave retarder component (12) and a further linear polarisation filter (13, 14).

Each of the polarisation filters is adapted to be disposed between the front of the

10   display discussed with respect to Figure 1 and an eye of an observer of such a display. In a preferred embodiment these filters may be integrated into eye glasses or similar types of apparatus to be worn over the eyes of an observer.

Each of the quarter wave retarder components (12) of each filter substantially are identical in the embodiment shown. The quarter wave retarders are employed to

15   convert the initially received elliptically polarised light from the front of the stereoscopic display through into spatially, linearly polarised light to be received by each linearly polarisation filter (13, 14).

Each of the linear polarisation filters (13, 14) are tuned to block a specific state of linearly polarised light to display a single image slightly spatially displaced from a

20   second source image to be shown by the second filter. The linear polarisation filters (13, 14) employed may use existing stereoscopic display techniques to decompose a single incoming light image into the pair original source images encoded by the stereoscopic display involved.

As can be appreciated by those skilled in the art the provision of the image

25   decoder (10) within a pair of eyeglasses worn by a wearer will eliminate any point

or angle of view variations perceived by the observer of the display. As the orientation of each linear polarisation filter (13, 14) is static with respect to the observer's eyes these types of variations may be eliminated in conjunction with the present invention in the embodiment discussed above.

5   The aspect described above the display is used to display spatially displaced images to the left and rights eyes of a viewer. The display can also be used to display different images to two viewers. In the same way as the two spatially displaced images can be encoded for alternative eyes, two different images can be encoded for different viewers using light polarising systems. The images are again

10   separated by the differently polarised glasses.

The set up is the same as described above. Instead of stereoscopic media two independent images are shown. Instead of having glasses with different polarisation filters at each lens the glasses will have the same polarisation filters. The first observer may have glasses with polarisation filter 13. The second will

15   have glasses with polarisation filters 14.

The first and second observers can therefore see independent images displayed on the same display.

This is advantageous as it allows people to watch different images on the same display. This is space saving in situations where people may wish to watch

20   different things for example in a car, where the driver may wish to see navigational information and the passenger may wish to watch a movie.

A further example is where the technology is integrated into a television set, different image streams are interlaced and separated using the polarisation. Different viewers can watch the different screens by wearing glasses of the

25   appropriate polarisation.

Further this can be used to provide security so that only someone wearing glasses of the correct polarisation can view the displayed image.

The circular polarisation is important in making the technology work for this application as it allows greater flexibility in the position of the viewer. Where

5   linearly polarised light is used, the viewer must be positioned in a 'sweet spot', making the technology impractical for use in situations where the position of viewers may change.

We now consider and discuss below the changes in polarisation states of light employed in conjunction with both the display (1) and decoder (10) discussed

10   above.

Let us assume that the light from 4 is unpolarised. The light from 5 is linearly polarised. Now we define an axis that is parallel to that linearly polarised light. The light leaving 5 is linearly polarised at 0 degrees to that axis. The light leaving 6 will have some degree of linear polarisation between 0 and 90 with respect to the axis.

15   From 7 the light is once again linearly polarised 90 degrees to the axis. The light leaving 8 will have some degree of linear polarisation between 90 and 0 with respect to the axis. The light leaving 9 will have a degree of elliptical polarisation ranging from left circularly polarised to right circularly polarised. If the light from 8 is rotated 45 degrees the light from 9 will be linearly polarised. We can now define

20   a second axis, axis2, which is 45 degrees to the original axis. We can also define a third axis, axis3, which is parallel to the fast axis of component 12. The light emitted by 12 is linearly polarised to the same angle with respect to axis3 as light emitted by 8 with respect to axis2. Light emitted from 13 and 14 is linearly polarised at an angle of +/- 45 degrees in relation to axis3 respectively.

We now consider the changes in light intensity affected by both the display (1) and decoder (10) provided in accordance with the embodiment of the invention discussed above.

Ideally there are only two places where the intensity is changed. If the light from 6 is linearly polarized at some angle other than the transmission axis of the polarizer (component 7) the intensity of light transmitted by 7 will be reduced.

The transmission axis of the components 13 and 14 are at a right angle. The angle of the linearly polarized light transmitted by component 8 sets the angle for the linearly polarized light transmitted by 12. The relative angle between what is transmitted by 12 and the linear polarisers 13 and 14 determines the intensity of the light transmitted to each eye shown.

Those skilled in the art should also appreciate that the above construction may also be implemented readily through the provision of existing componentry. To do so first we start with an LCD panel. We remove the polarisers. We then laminate a sheet of quarter wave retarder to the front of the panel. The fast axis of the retarder is orientated at + or - 45 degrees to the rubbing axis of the LCD panel. This construction can then be assembled onto the front of a normal high brightness LCD monitor.

Aspects of the present invention have been described by way of example only and it should be appreciated that modifications and additions may be made thereto without departing from the scope thereof.

WHAT WE CLAIM IS:

1.   A stereoscopic display adapted to present a stereoscopic image composed of a plurality of pixels, the display including,

        a light intensity encoder adapted to emit light from a plurality of pixels with an assigned light intensity for each pixel, and

        a light polarisation encoder adapted to receive light emitted from the light intensity encoder and to emit said light with an assigned polarisation state for each pixel,

        wherein the light polarisation encoder is adapted to emit light polarised with a non-spatial polarisation.

2.   A stereoscopic display as claimed in claim 1 wherein the light intensity emitted for a pixel is determined at least in part by the light intensities of pixels making up two spatially displaced images of the scene which the stereoscopic display is to present.

3.   A stereoscopic display as claimed in claim 1 or claim 2 wherein a light intensity encoder includes a liquid crystal display.

4.   A stereoscopic display as claimed in claim 3 wherein a light intensity encoder includes a linear polariser in the transmission path of the liquid crystal display.

5.   A stereoscopic display as claimed in claim 1 or claim 2 wherein the light intensity encoder includes an image projection system.

6.   A stereoscopic display as claimed in claim 1 or claim 2 wherein the light intensity encoder includes a cathode ray tube.

7.   A stereoscopic display as claimed in any previous claim wherein the polarisation state of light emitted from the stereoscopic display is controlled by the light polarisation encoder.

8.   A stereoscopic display as claimed in claim 7 wherein the polarisation state assigned for a pixel is determined at least in part by the intensities of pixels making up two spatially displaced images of the scene which the stereoscopic display is to present.

9.   A stereoscopic display as claimed in any previous claim wherein a light polarisation encoder includes a twisted nematic liquid crystal matrix adapted to receive light from the light intensity encoder.

10.   A stereoscopic display as claimed in claim 9 wherein the twisted nematic liquid crystal matrix controls the angular polarisation state of light emitted from the light intensity encoder.

11.   A stereoscopic display as claimed in any previous claim wherein a light polarisation encoder includes a quarter wave retarder component.

12.   A stereoscopic display as claimed in claim 11 wherein the quarter wave retarder components converts rotated linearly polarised light into elliptically polarised light having a non-spatial polarisation.

13.   A stereoscopic display as claimed in any previous claim wherein a diffuser is located between the light intensity encoder and the light polarisation encoder.

14.   A stereoscopic display as claimed in any one of claims 1 to 12 wherein in a refractor is located between the light intensity encoder and the light polarisation encoder.

15.   A stereoscopic display as claimed in any previous claim which includes an intensity assignment processor adapted to determine the light intensity to be assigned to each pixel of the image to be displayed.

16.   A stereoscopic display as claimed in any previous claim which includes a polarisation assignment processor adapted to determine the polarisation state to be assigned to each pixel of the image to be displayed.

17.   A method of providing an intensity assignment processor through computer readable instructions, said instructions being adapted to execute of the steps of;

   i)   determining an intensity value for at least one pixel of a left input image, defined as I_l for each pixel investigated, and

   ii)   determining an intensity value for at least one pixel of a right input image, defined as I_r for each pixel investigated, and

   iii) calculating the intensity to be assigned by the intensity assignment processor provided, said assigned intensity defined as I_a, being proportional to

$$I_a \; \alpha \; \sqrt{(I_l)^2 + (I_r)^2}$$

18.   A method of providing a polarisation assignment processor through computer readable instructions, said instructions being adapted to execute of the steps of;

   i)   determining an intensity value for at least one pixel of a left input image, defined as I_l for each pixel investigated, and

   ii)   determining an intensity value for at least one pixel of a right input image, defined as I_r for each pixel investigated, and

iii)   calculating the polarisation to be assigned by the intensity assignment processor provided, said assigned polarisation defined as P_a, being proportional to

$$P_a \ \alpha \ arctan \ (I_r / I_i)$$

19.   A stereoscopic image decoder which includes two polarisation filters with each filter to be positioned between a stereoscopic display and an eye of an observer of said stereoscopic display,

wherein the first polarisation filter is adapted to block non-spatially polarised light in a first polarisation state, where said non-spatially polarised light in a first polarisation state is emitted by the second polarisation filter, and

the second polarisation filter is adapted to block non-spatially polarised light in a second polarisation state, wherein said non-spatially polarised light in a second polarisation state is emitted by the first polarisation filter.

20.   A stereoscopic image decoder as claimed in claim 19 wherein a polarisation filter includes a quarter wave retarder component combined with a linear polarisation filter.

21.   A stereoscopic display system which includes a stereoscopic display as claimed in any one of claims 1 to 16 and at least one stereoscopic image decoder as claimed in any one of claims 19 to 22

22.   Computer readable instructions which when run are adapted to provide an intensity assignment processor of a stereoscopic display substantially as herein described with reference to and as illustrated by the accompanying drawings and/or examples.

23.   Computer readable instructions which when run are adapted to provide a

polarisation assignment processor of a stereoscopic display substantially as herein described with reference to and as illustrated by the accompanying drawings and/or examples.

24.   A stereoscopic display substantially as herein described with reference to and as illustrated by the accompanying drawings and/or examples.

25.   A stereoscopic image decoder substantially as herein described with reference to and as illustrated by the accompanying drawings and/or examples.
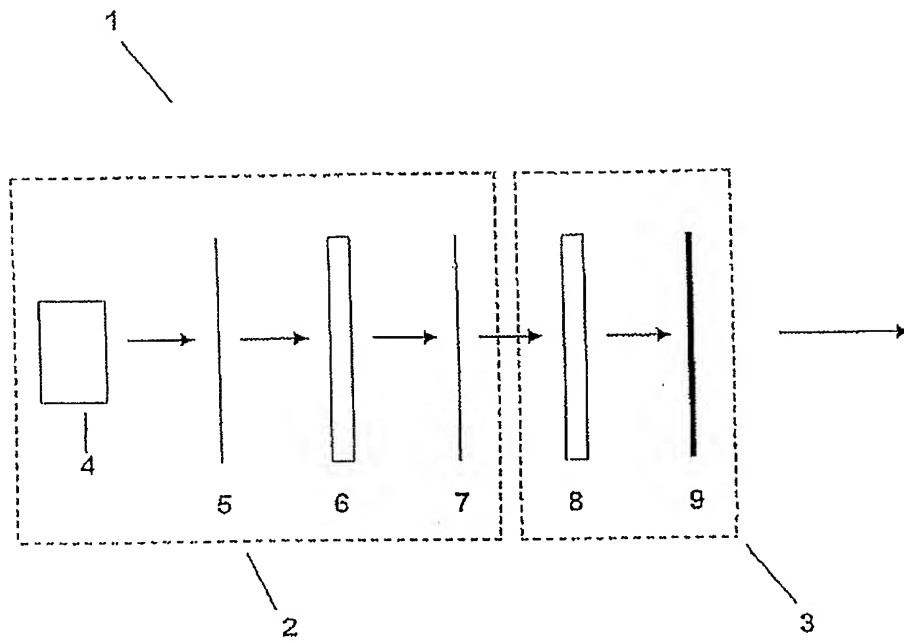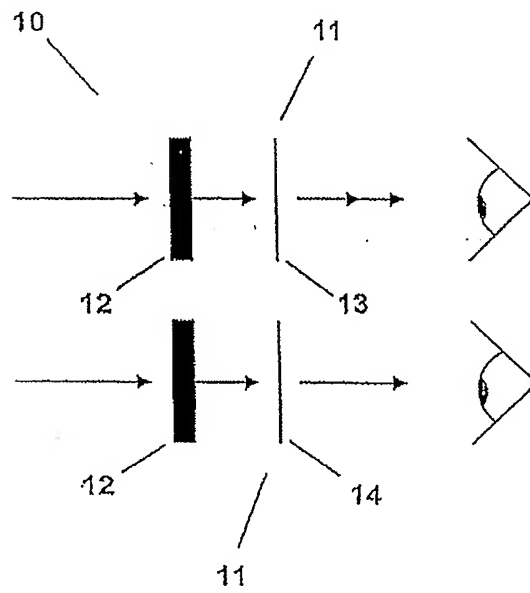
Figure 1

Figure 2

A.	CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

H04N 13/00 (2006.01)   *G02F 1/1335* (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B.	FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPAT & IEEE: stereoscopic, polarisation, intensity, pixel and similar terms,

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6,359,664 B1 (FARIS) 19 March 2002 Whole document	1-16
A	US 6,181,303 B1 (JOHNSON et al) 30 January 2001 Whole document	1-16
A	EP 1 067 805 A2 (SHARP KABUSHIKI KAISHA) 10 January 2001 Whole document	1-16
A	GB 2 296 099 A (SHARP KABUSHIKI KAISHA) 19 June 1996 Whole document	1-16

☐ Further documents are listed in the continuation of Box C	☒ See patent family annex

*	Special categories of cited documents:		
"A"	document defining the general state of the art which is not considered to be of particular relevance	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E"	earlier application or patent but published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
10 February 2006	**17 FEB 2006**

Name and mailing address of the ISA/AU	Authorized officer
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	**James Williams** Telephone No : (02) 6283 2599

Form PCT/ISA/210 (second sheet) (April 2005)

Box No. II   Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:

   because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:

   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:

   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III   Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
   See Extra Sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: 1-16

Remark on Protest   ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Supplemental Box
(To be used when the space in any of Boxes I to VIII is not sufficient)

Continuation of Box No: III

The claims do not relate to one invention only (or to a group of inventions so linked as to form a single general inventive concept). In assessing whether there is more than one invention claimed, I have given consideration to those features which can be considered to be "special technical features". These are features that potentially distinguish the claimed combination of features from the prior art. Where different claims have different special technical features they define different inventions. I have found claims having different special technical features as follows:

(1) Claims 1-16 directed to a stereoscopic display. It is considered that the combination of a light intensity encoder, a light polarisation encoder and the use of non-spatial polarisation comprises a first special technical feature.

(2) Claim 17 directed to a method for intensity assignment. It is considered that calculating the intensity to be assigned as per the formula given comprises a second special technical feature.

(2) Claim 18 directed to a method for polarisation assignment. It is considered that calculating the polarisation to be assigned as per the formula given comprises a third special technical feature

(2) Claim 19 directed to a stereoscopic image decoder. It is considered that having two polarisation filters comprises a fourth special technical feature

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Member					
US 6359664	AU	11510/97	AU	22106/97	AU	23968/95
	AU	31229/97	AU	41290/96	AU	41597/96
	AU	42066/00	AU	44256/99	AU	45877/97
	AU	48554/00	AU	49017/96	AU	52452/98
	AU	64394/98	AU	76014/96	AU	83908/98
	AU	2003273244	CA	2333871	CA	2369364
	CN	1217796	CN	1312918	CN	1359479
	DE	19729634	EP	0760965	EP	0873537
	EP	0946671	EP	0946787	EP	0968456
	EP	0994775	EP	1093598	EP	1175639
	EP	1423336	HK	1025348	KR	2000053072
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	US	5599412	US	5680233	US	5691789
	US	5801793	US	5821989	US	5828427
	US	5844717	US	5874341	US	5886816
	US	5889437	US	5940150	US	6002518
	US	6005272	US	6011581	US	6028649
	US	6034717	US	6034753	US	6072549
	US	6104447	US	6133980	US	6181395
	US	6188460	US	6333773	US	6338807
	US	6369868	US	6377325	US	6384971
	US	6404464	US	6414728	US	6456432
	US	6473143	US	6532049	US	6535268
	US	6551526	US	6556236	US	6559903
	US	6573961	US	6583827	US	6630974
	US	6633354	US	6661486	US	6671008
	US	6697133	US	6710823	US	6738114
	US	6753044	US	6798639	US	6805776
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		GB	2296151	JP	8240790	US	5917562

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX